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The root growth of forage grasses at different soil P levels

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Abstract

The size of forage grass roots have a significant impact on the nutrient use efficiency. Our aim was to examine how initial soil P fertility level (Fair P 6,2 mg P l^{-1} soil, Good P 17,5 mg P l^{-1} soil) and annual P application (20 kg P ha^{-1}) contribute to the above- and belowground growth of silage grass. The field trial was located at Kotkaniemi experimental farm (Yara Suomi Ltd., Finland) where the two soil P levels were created in a 40-years fertilization experiment. Plant and root samples (cylinder 20 cm depth, ø 10 cm) were taken at the time of the first harvest and three times after the harvest, and root and shoot dry mass (DM) was measured and shoot:root -ratio (S:R) was calculated. Significantly higher root DM was measured when the soil P level was good and P was applied (Good P20). Root decay was observed in all treatments after harvest. In general, low S:R was measured due to a long period of water deficit and temperatures above the long-term average. Our results indicate that good P supply, either from soil or by additional fertilization, has a positive impact on grass root growth.

Keywords: Grass root, soil P level, shoot:root -ratio, P fertilization

Introduction

Most of the living grass biomass, over 60%, is beneath the surface (Gibson, 2009) and 70−90% of roots are in the 0−20 cm depth (Bolinder *et al*., 2002). Silage grasses are harvested multiple times in growing season, and it has been shown that the root growth is reduced for 6−18 days after harvests. The growth cessation depends on the extent of aboveground biomass removal (Crider, 1955). Simultaneously with the root growth cessation, nutrient uptake such as P is also decreased (e.g. Oswalt *et al*., 1959). Among other nutrients, the availability of N and P affects root growth. In Italian ryegrass (*Lolium multiflorum* L.) N fertilization is shown to increase shoot:root -ratio (S:R), root dry mass (DM) and root area, but decrease the specific length (Henry *et al*., 2005). The results of P fertilization effects on root DM and length are somewhat contradictory as some studies show no effect of P fertilization on root growth (Ros *et al*., 2018) and in other studies the results depended on the species (Waddell *et al*., 2017). The objective of our study was to examine how soil P fertility level and P application affected the above- and belowground growth of silage grass.

Materials and methods

The effects of two soil fertility P levels (Fair: 6,2 mg P l^{-1} soil; Good: 17,5 mg P l^{-1} soil) and annual P fertilization (P0: 0 P kg ha^{-1} and P20: 20 P kg ha^{-1}) to silage grass ((timothy (*Phleum pratense* L.), meadow fescue (*Schedonorus pratensis* Huds.), tall fescue (*Schedonorus arundinaceus* Schreb.)) root growth were evaluated in a field trial in third year grass ley located at Kotkaniemi experimental farm (Yara Suomi Ltd., Finland). Soil P levels ranging from low to high were created in a previous, static 40-year long-term fertilization experiment with increasing NPK levels. The soil type of the experimental site was clay loam. The plots with three replicates were harvested three times during the growing period and fertilized with N-P-K-S fertilizer (250/250−0/20−200/200−0/1,2). In 2018, the plots were irrigated (20 mm) a week after the first harvest due to a long drought period. One plant and root sample (cylinder height 20 cm, ø 10 cm) was taken from each plot (three replicates) a week before the first harvest (May 24) and three times after the first harvest (June 5, 19 and 26). After sampling, the soil samples were soaked in water for 2 h and the roots were washed using 3,55 mm and 1,0 mm sieves to collect all roots. Four individual timothy plants with roots were separated and photographed. Separated plants were added back to sample taken with cylinder from ley mixture, shoots were separated from roots from the root neck. Roots and shoots were dried at 60 °C to constant weight. Root and shoot dry mass (DM) was measured and converted to g m^{-2} form and S:R was calculated. Root area (m^2 m^{-2}) and diameter (mm) were analysed from the images by using Image J program. Analysis of variance (ANOVA) was performed to compare differences between all treatments and sampling dates. Means were compared using Fisher’s Least Significant Difference (LSD) when the F-value in the ANOVA was statistically significant ($P < 0,05$).

Results and discussion

Soil P level and P application had a positive effect on root DM at the time of harvest and immediately after harvest (Figure 1). The root DM was measured significantly higher one week before harvest than 20 or 27 days after harvest when P was applied (FairP20 and GoodP20). Root decay was observed in all treatments after harvest and a full recovery of the root DM was not observed within a month.

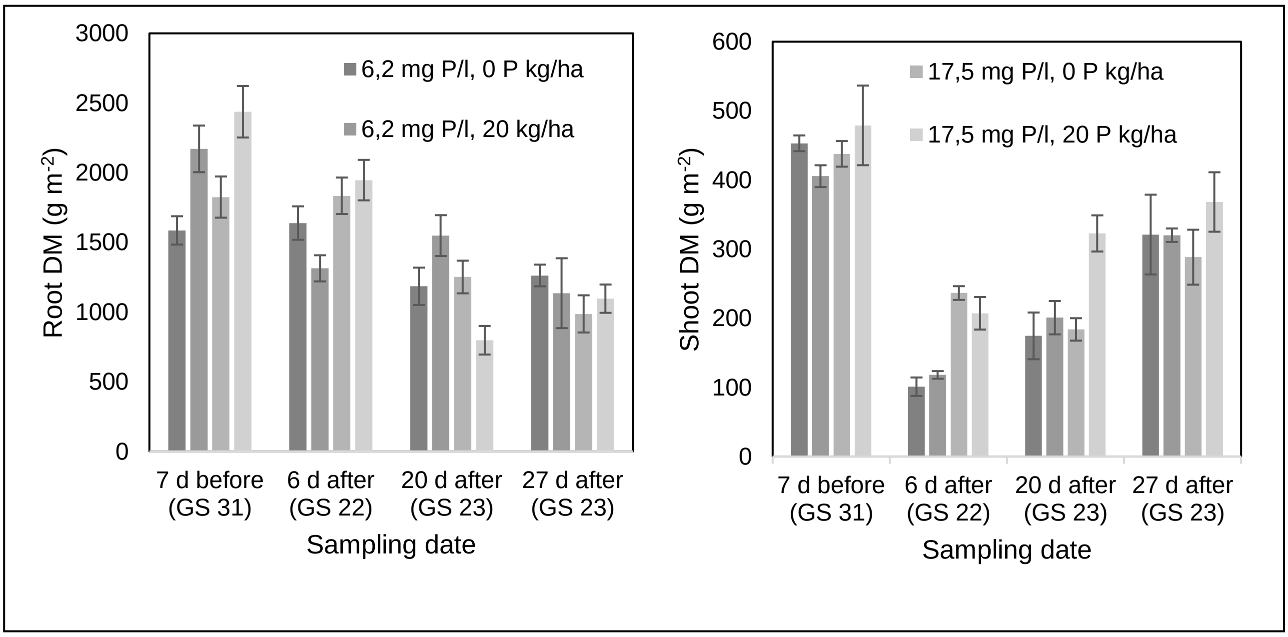

Figure 1. a) Root dry mass (DM, in the soil layer of 0−20 cm) and b) shoot DM (g m^{-2}) means of four treatments (low soil P fertility level 6,2 mg P l^{-1} soil with 0 and 20 P kg ha^{-1} fertilization and high soil P fertility level 17,5 mg P l^{-1} with 0 and 20 P kg ha^{-1} fertilization) a week before harvest and three times (6, 20 and 27 days) after harvest and the growth stages (GS). The data shown are means ± standard error (SE), n = 3.

In the aboveground biomass no differences were observed at harvest. Differences in regrowth between the treatments in the aboveground growth also levelled off during the monitoring period, even though the regrowth was slightly faster in Good P20 treatment. The long period of water deficit and temperatures above the long-term average during the spring and summer explains the low above ground biomass. Root area (m^2 m^{-2}) varied between 0,005 to 0,008 being the lowest in Good P20 treatment whereas the mean root thickness was approximately 0,2 mm and it was unaffected by the treatment.

In the first harvest S:R was between 0,13-0,35 which is comparable with the results of Bolinder *et al*. (2002) who found the S:R between 0,16-0,75 for grasses. Low S:R may be caused by long period of water deficit and temperature over long-term average in spring and summer as significant amounts of the biomass accumulated in roots rather than shoots.

Conclusion

Root DM was greatest in Good P20 treatment at the time of harvest and immediately after it. This indicates that good P availability, either from soil or by additional fertilization had a positive impact on grass root growth. However, more study of the effects of soil P availability and P fertilization to grass root growth is needed.

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